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# Investigating the Views of Pre-service Science Teachers on STEM Education Practices

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**ABSTRACT**

It has given importance to the development of 21st century skills in every aspect of life. STEM (Science, Technology, Engineering, and Mathematics) education has played an important role to improve these skills and teachers are expected to be able to organize learning environments accordingly. The purpose of this research is to examine the pre-service science teachers' views on STEM education practices. The case study method was used in this research and participants of the research are 7 pre-service science teachers (4 female, 3 male). In the research STEM activities were applied during 8 weeks. The data of this research were collected through semi-structured interviews. The content analysis was used for data analysis and data were converted to the tables. During the interviews, it was noted that the pre-service science teachers wanted to apply STEM education when they become teachers; they wanted to get advanced knowledge about STEM education. In addition, pre-service science teachers have expressed their opinions on the basic rationale, benefits and limitations of STEM education, and have made proposals for the development and dissemination of STEM education. Pre-service science teachers learned about STEM education and how to implement it, by the help of STEM education practices that was conducted within the scope of this research. Pre-service teachers who are future teachers need to be informed and trained about STEM education.

**KEYWORDS**
STEM education practices, science education, pre-service science teachers' views

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## Introduction

Individuals who are inquisitive on science, productive, open to innovation, entrepreneur, problem solver and lifelong learner, need to be trained and new needs that emerge in education must be met. Education environments should offer students the

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opportunity in order to develop 21st century skills. Necessary skills for the 21st century: 1.Critical thinking and problem-solving; 2. Collaboration across networks and leading by influence; 3. Agility and adaptability; 4. Initiative and entrepreneurialism; 5. Effective oral and written communication; 6. Accessing and analyzing information; and 7. Curiosity and imagination (Wagner, 2008). STEM education plays an important role in the development of 21st century skills. STEM education, which provides the integration of disciplines of science, technology, engineering and mathematics, is an innovative approach and supports the upbringing of science and technology literate individuals. "Contemporary STEM originated in the 1990s at the National Science Foundation (NSF) as an acronym for science, technology, engineering, and mathematics" (Bybee, 2013, p.1). STEM education is an approach which brings together disciplines, leads to effective and quality learning, experiences concerning to daily life and involves military, economic, high-level thinking (Yıldırım and Altun, 2015). According to Akyıldız (2014), STEM education is an integrated, interdisciplinary approach that provides relevant and practical learning experiences for students. Educational reforms in many countries focused on STEM and increasing the interest in teaching of STEM (Corlu, Capraro and Capraro, 2014). The need for the number of people who developed themselves in STEM professions revealed the need for STEM education (Öner and Capraro, 2016) and the benefits of STEM education in the literature related to the subject are expressed as follows (Akbaba, 2017; Bybee, 2010; Elliott, Oty, McArthur and Clark, 2001;Gülhan and Şahin, 2016; Kennedy and Odell, 2014; Morrison, 2006; Olivarez, 2012; Ricks, 2006; Roberts, 2012; Sahin, Ayar and Adıguzel, 2014; Yamak, Bulut and Dündar, 2014):

1- It presents students an interdisciplinary perspective.
2- It develops 21st Century skills.
3- It develops creative problem-solving, critical thinking, and scientific process skills.
4- It contributes to developing a positive attitude towards STEM disciplines.
5- It contributes to the economic development of the countries.
6- It develops engineering skills.
7- It provides the permanence of knowledge.
8- It brings along academic achievement.
9- It supports the upbringing of individuals who are innovative, inventor, self-confident, reasoner and technology literate.

STEM is an education reform (Bybee, 2013). Therefore, it is important that the teachers and pre-service teachers who are the practitioners of reform movements in education are trained in STEM education. "Future STEM teachers can be facilitated by having pre-service teacher education programs focus on nurturing the development of" (Lee and Nason, 2012, p. 34):

1. Both within-discipline and trans-disciplinary STEM Knowledge;
2. Situated theoretical knowledge to underpin informed STEM educational practice; and
3. Positive attitudes and disposition towards STEM.

When the relevant literature is examined, it has been determined that studies which examine the views of teachers and pre-service teachers on STEM education (Eroglu and Bektas, 2016; Kızılay, 2016) are not sufficient. Eroglu and Bektas (2016) worked with five science teachers in their work to reveal the opinions of science teachers on STEM and STEM-based practices.The data of the study were obtained from semi-structured interview method and evaluated by content analysis. As a result of the analysis, it is seen that the teachers relate STEM-based practices to the field of physics; science lessons to technology,

engineering to mathematics. In addition, it has been determined that teachers want to apply STEM-based activities but there is no time and material in this regard.

Kızılay (2016) has worked with 25 pre-service teachers to determine their opinions on STEM fields and education. The data of the research was obtained by interview method. The data obtained through interviews was analyzed by content and descriptive analysis. In results of interviews conducted, pre-service teachers have stated that engineering made human life easier and revealed product; science and mathematics were used in engineering; technology depended on engineering and vice versa; it is also stated that there is a mutual development between science and technology, and mathematics is essential for technology. In addition, pre-service teachers have stated that the use of engineering and technology is essential in science and mathematics education, and the STEM fields are linked to each other.

In this research, the opinions of pre-service science teachers on STEM education practices were examined. For this purpose, it was interviewed with 7 pre-service science teachers and the obtained data were evaluated by content analysis. When the literature on STEM education is examined, it appears that there is a limited number of studies on the practical implementations of STEM education, which examine the opinions of pre-service teachers on the basic rationale, benefits, and limitations of STEM education practices. In addition, different from previous studies, the opinions of pre-service teachers about how STEM education can be developed and disseminated, how to get advanced knowledge about STEM education and how to apply STEM education when being a teacher, are also examined in this study. Therefore, it is thought that the study will contribute to the literature on STEM education.

### *Problem statement*

The problem sentence of this research is “What are the views of pre-service science teachers about STEM education practices?”

## Methodology

### *Research model*

In this research, it was aimed at investigating the opinions of prospective science teachers about STEM education practices; and the case study model from qualitative research methods was used. “Case studies deal with a person, community, event or situation in their own context. Therefore, the purpose of the case studies is not to generalize the results, but to reveal the attitudes or behaviors of sample against to an event "(Ersoy, 2016, p. 3-4).

### *Participants*

Participants of this research are 7 pre-service science teachers (4 female, 3 male) who are 3rd grade students. The participants were volunteered to participate in the research. The average age of participants is 21. Codenames (S1, S2, S3, S4, S5, S6, S7) were given to the pre-service science teachers in the direction of the research ethics.

### *Implementation process*

STEM activities based on interdisciplinary approaches that will make learning more enjoyable and easier for pre-service teachers were taken part in this research. Applied activities are given in Table 1. STEM activities were performed for 8 weeks. Activities were took place for 2 hour per week. Prior to the start of the implementation, pre-service science teachers were informed about what STEM education is. STEM activities were implemented by given own designs of pre-service teachers. In addition, pre-service teachers were asked to associate the activities and materials with a science topic and study on subject before making

the activity, to discuss the achievements they have achieved from the activity and to associate them to daily life. For example; an activity concerning to wind turbines was held. In this activity, students were asked to discuss which materials they will use to make the propeller wings, and make wind turbines with these materials. For instance, a student stated that the lifetime of the board is long and that it is more useful to make the propeller wings from the board, and he used the board in his material. Another student made a wind turbine with plastic wings by indicating that the plastic wings are lighter than the board.

Table 1. Activities

| Week | Activities |
|---|---|
| 1 | Introduction of STEM Education |
| 2 | Ventilating Fan Construction |
| 3 | Solar Vehicle Construction |
| 4 | Crane Construction |
| 5 | Wind Turbines Construction |
| 6 | Helicopter Construction |
| 7 | Car Construction |
| 8 | Bicycle Construction |

## *Data collection and data analysis:*

In this research, the data related to the opinions of pre-service science teachers about the basic rationale of STEM education, its benefits, limitations and how to improve and disseminate it were collected. The pre-service science teachers' opinions on STEM education were obtained from semi-structured interviews. Semi-structured interviews were conducted with 7 volunteer pre-service science teachers. After the STEM education practices, an interview was made with pre-service science teachers. A total of 80 minutes were recorded. 35 pages of written documents were obtained from voice recordings. It has been provided that a part of the voice recordings are listened by another researcher, and the written documents are arranged according to the criticisms. In addition, while the questions asked in the semi-structured interviews with the pre-service science teachers were being prepared, the opinions of the 2 experts working on STEM education were consulted and necessary corrections were made. The interview questions are as follows:

1. What is the basic rationale of STEM education?
2. Would you like to apply STEM education in your classroom as a teacher?
3. Would you like to get advanced level of information about STEM education?
4. What kind of project can you produce to develop and disseminate STEM education?
5. What differences did STEM education provide for you? What are the benefits?
6. What are the limitations of STEM education?

Semi-structured interviews about STEM education practices were evaluated according to content analysis. "In content analysis, there is the interpretation of combining similar data and organizing them in a way that the reader can understand." (Yıldırım and Şimşek, 2013, p. 259). The codes were generated from obtained data from semi-structured interviews are shown in table. Coding reliability by two researchers was 99% for semi-structured interviews.

### Findings

In this section, findings and interpretations related to the opinions of pre-service science teachers on STEM education are given.

At the end of the practices, the question "What is the basic rationale of STEM education for you?" was asked to the pre-service science teachers and the answers given to this question are given in Table 2.

**Table 2.** Pre-service science teachers' opinions on the basic rationale of STEM education.

| Codes | Participant |
|---|---|
| Getting the individual ready for real life problems | S5, S7 |
| Developing the psychomotor and mental skills of the individual | S6 |
| Establishing a relationship between disciplines | S3 |
| Improving the designing skill | S1 |
| Developing the skills of 21st century | S2 |
| Providing the permanence of knowledge through learning by doing and living | S4 |

According to Table 2, pre-service science teachers codenamed S5 and S7 indicate that the basic rationale for STEM education is to prepare the individual for real life problems and the candidate codenamed S6 indicates that is to develop the psychomotor and mental skills of the individual, and for the other candidate codenamed S3, it is establishing a relationship between disciplines. In addition, pre-service science teachers stated that the basic rationale of STEM education is to develop the designing skills (S1), to develop the skills of 21st century (S2) and to provide the permanence of knowledge through learning by doing and living (S4). Some examples from the opinions given in Table 2:

*S3: I think the basic rationale of STEM education is to be able to use different disciplines like science, technology, mathematics and engineering together.*

*S4: According to the researches, when we learn through touching and seeing, it makes the knowledge more permanent. That is to say, the information we learn by doing and living is permanent. I think that is the basic rationale of STEM education.*

The question "Do you want to apply STEM education in your classroom as a teacher?" was asked to pre-service science teachers and the answers they gave to this question are given in Table 3.

**Table 3.** Pre-service science teachers' opinions on the question "Do you want to apply STEM education in your classroom as a teacher?"

| Codes | Participant |
|---|---|
| I would like to apply STEM education practices in my classroom. | S2, S3, S5, S6, S7 |
| I do not want to apply STEM education practices in my classroom. | S1, S4 |

According to the Table 3, it can be understood that the pre-service teachers named S2, S3, S5, S6 and S7 indicate that they would like to apply STEM education practices in their classroom. On the other hand, pre-service teachers who are codenamed S1 and S4 indicate that they don't want to apply STEM education practices in their classroom. Some examples from the opinions given in Table 3:

*S4: I don't want to apply it. I think it is not necessary. We do not train engineer here.*

*S5: I would like to apply it, because STEM education makes things clearer. Thus, students are more likely to attend classes and learn more easily.*

The question "Would you like to get advanced level of information about STEM education?" was asked to science teacher candidates and the answers they gave to this question are given in Table 4.

**Table 4.** Pre-service science teachers' opinions on the question "Would you like to get advanced level of information about STEM education?"

| Codes | Participant |
|---|---|
| Yes, I would like to get advanced level of information about STEM education. | S3, S5, S6, S7 |
| No, I don't want to get advanced level of information about STEM education. | S1, S2, S4 |

According to the Table 4, it can be seen that while the pre-service teachers codenamed S3, S5, S6, and S7 would like to get advanced level of information about STEM education, the pre-service teachers codenamed S1, S2 and S4 don't want to get advanced level of information about STEM education. Some examples from the opinions of pre-service science teachers in this regard are given below:

*S4: Since, I'm not interested, I don't want to get advanced level of information about STEM education.*

*S5: Yes, I will spend extra time in STEM education after this course. We've stated that we should have an elective course related to STEM education. In addition, I've decided to leave the science education department. I will study engineering instead.*

The question "What kind of project can you produce to develop and disseminate STEM education?" was asked to pre-service teachers and the answers they gave to this question are given in Table 5.

**Table 5.** Pre-service science teachers'opinions on the question "What kind of project can you produce to develop and disseminate STEM education?"

| Codes | Participant |
|---|---|
| A project can be designed to encourage STEM education in the pre-school period. | S1 |
| A project related to the establishment of STEM education centers can be designed. | S2, S3 |
| A project can be designed to introduce STEM education through seminars and conferences. | S4 |
| A project can be designed about dissemination of STEM education in universities. | S5 |
| A project can be designed about dissemination of STEM education in formal and non-formal education. | S6 |
| A project to integrate STEM education with biology and chemistry courses can be designed. | S7 |

According to Table 5, a project to encourage STEM education in the pre-school period (S1), a project related to the establishment of STEM educational centers (S2, S3), a project to introduce STEM education for pre-service science teachers' through seminars and conferences (S4) were proposed. A project can be designed about the dissemination of STEM education in universities was proposed (S5), a project can be designed about dissemination of STEM education in formal and non-formal education (S6) and a project to integrate STEM education with biology and chemistry courses (S7) were proposed. Here are some examples of proposals from pre-service science teachers' related to this topic:

*S1: I think that STEM education should be provided from early childhood ages. Since, imagination skill of a child is better than ours. Therefore, a project can be designed about providing this education from a young age.*

*S5: As far as I know, STEM education is not currently being provided at many universities. This approach needs to be applied more in courses. Therefore, a project can be designed about dissemination of STEM education in universities.*

*S7: For now, STEM education seems mostly related to physics. A project to integrate STEM education with biology and chemistry courses can be designed.*

The questions "What differences did STEM education provide for you? What are the benefits?" were asked to science teacher candidates and the answers are given in Table 6.

**Table 6.** Pre-service science teachers' opinions on the questions "What differences did STEM education provide for you? What are the benefits?"

| Codes | Participant |
|---|---|
| It provided me think about topics by integrating them to each other. | S3 |
| It helped me improve my imagination. | S2, S7 |
| It helped me improve my handcrafting skills. | S5, S7, S3, S2 |
| It helped me observe nature, livings and objects better. | S3, S6 |
| It helped me improve my designing skills. | S5 |
| It helped me improve myself cognitively in the subjects of physics. | S6 |
| I am more interested in my lessons. | S5, S7 |
| It helped me become more productive. | S7 |
| It helped me improve my engineering skills. | S5 |
| It helps presence of knowledge through learning by doing and living. | S6, S7, S3, S2 |
| Provides interdisciplinary integration. | S6 |
| Develops high-level thinking skills. | S2, S5 |
| Develops students' ability to design projects. | S7 |
| It makes learning enjoyable. | S6 |
| There was no positive effect. | S1, S4 |

According the Table 6, STEM education practices help teacher candidates improve their imagination, handcrafting skills, observation skills, designing skills, engineering skills and high-level thinking skills; help the presence of the knowledge through learning by doing and living, become more productive and more interested in lessons; help them develop their ability to design projects; made the learning process more enjoyable. In addition, codenamed S1 and S4 indicated that there is no positive effect of STEM education practices. Here are some examples of proposals from pre-service science teachers'related to this topic:

*S1: I do not think these practices have any positive effect on me.*

*S3: I think STEM education ensures that the information to be learned is permanent. It enables us to learn by living and doing not by memorization method. In addition, these practices provided me think about topics by integrating them to each other. I wasn't able to do it before.*

The question "What are the limitations of STEM education?" was asked to pre-service teachers and the answers they gave to this question are given in Table 7.

**Table 7.** Pre-service science teachers' opinions on the question "What are the limitations of STEM education?".

| Codes | Participant |
|---|---|
| Students with physical disabilities may find it difficult to carry out the designs involved in STEM approach. | S5 |
| They can only be associated with topics in physics. They can't be associated with topics in biology and chemistry courses. | S2, S3, S5, S6, S7 |
| STEM education practices are time consuming. | S1, S3, S4, S5, S6, S7 |
| STEM education practices are costly practices. | S7 |

According to Table 7, the pre-service teacher codenamed S5 stated students with physical disabilities may find it difficult to carry out the designs involved in STEM approach; the pre-service teacher who are codenamed S2, S3, S5, S6 and S7 stated that

STEM education practices can only be associated with topics in physics. They cannot be associated with topics in biology and chemistry courses; the teacher candidates who are codenamed S1, S3, S4, S6 stated that STEM education practices are time consuming. In addition, the teacher candidates indicated that STEM education practices are costly practices (S7). Some examples from the opinions of pre-service science teachers:

*S3: It is a limitation that it can only be used in physics classes and not in chemistry and biology classes.*

*S7: I think STEM approach is time consuming and costly.*

## Discussion and conclusion

In this research, it has been confirmed that pre-service science teachers generally have positive opinions on STEM education practices. Similar with the results reached in this research, it has confirmed that teachers and pre-service teachers have positive opinions on STEM with the applications in many researches (Eroglu and Bektas, 2016; Kızılay, 2016). Similarly, in the research of Cinar, Pirasa and Sadoglu (2016), it was determined that pre-service science and mathematics teachers had positive opinions on STEM education. In their research, Freeman, Alston, and Winborne (2008) stated that STEM education also improved attitudes of pre-service teachers towards science. In this research, it was determined that pre-service science teachers prefer to apply STEM education and they want to get advanced level of information about STEM education as teachers. However, there are also pre-service teachers who do not like STEM education and do not want to apply it when they are teachers. For example, a prospective teacher with S4 nickname explains this situation as follows: “I don’t want to apply STEM education. I think it is not necessary. We do not train engineer here.” In addition, pre-service teachers have proposed proposals for the development and dissemination of STEM education. For example; they stated that a project could be designed to encourage STEM education in the pre-school period. Similarly, in the research of Yıldırım and Selvi (2016), pre-service teachers have emphasized that STEM education should be given from early ages. Soylu (2016) and Katz (2010) stated that STEM education should be given from pre-school period also.

Pre-service teachers also indicated that the basic rationale of STEM education is to prepare the individual for real life conditions, to develop the psychomotor and mental skills of the individual, to establish interdisciplinary integration, to improve the designing skills, to provide the improvement of 21st century skills. In addition, pre-service science teachers have stated that STEM education practices help the teacher candidates improve their imagination, handcrafting skills, observation skills, designing skills, engineering skills and high-level thinking skills; help the permanence of the knowledge through learning by doing and living, become more productive and more interested in lessons; help them develop their ability to design projects; made the learning process more enjoyable. Similarly, in the research of Yıldırım and Selvi (2016), pre-service teachers have stated that STEM education is fun, making it possible to learn by living and doing, and developing imagination, productivity and psychomotor skills.

In this research, pre-service science teachers pointed out the limitations of STEM education and stated that STEM education practices could only be associated with topics in physics. They couldn't be associated with topics in biology and chemistry courses. It was also pointed out that STEM education practices are costly practices and time consuming. The misconceptions that pre-service teachers have about STEM education have also been identified in the research conducted by Eroglu and Bektas (2016) and Yıldırım and Selvi (2016). In the research of Eroglu and Bektas (2016), pre-service science teachers had associated STEM-based activities with the topics in physics also. Similarly, in the research of

Yıldırım and Selvi (2016), pre-service teachers indicated that STEM education was suitable only for physics lessons.

"Nations need an innovative STEM workforce to be competitive in the 21st century and the immediate goal of STEM initiatives is to increase the number and quality of STEM teachers" (Corlu, Capraro and Capraro, 2014, p. 75-77). Teachers play a key role in the training of qualified individuals in accordance with the needs of the age. In this context, it is important to ensure that teachers who are practitioners of educational reform movements are qualified in STEM education. Therefore, teachers and pre-service teachers should be supported in order to have the necessary field knowledge and pedagogical knowledge related to planning and implementation in accordance with the STEM education, and provided with the necessary resources and materials. (Altan, Yamak and Kırıkkaya, 2016; Corlu, Capraro and Capraro, 2014; Gonzalez and Kuenzi, 2012; Kennedy and Odell, 2014; Stohlmann, Moore and Roehrig, 2012). With this research, pre-service teachers have had the opportunity to learn about STEM education practices and have gained awareness that knowledge should also be applied in their teaching lives.

## Suggestion

In the direction of the results obtained from this research, some suggestions are presented below:

1. Pre-service teachers should be ensured to gain an interdisciplinary perspective by giving lessons on STEM education and practices, and teacher education programs should be organized accordingly.
2. Seminars and conferences should be organized in order to introduce, develop and disseminate STEM education; STEM education centers should be established.
3. STEM education should begin at early ages.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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